TECHNOLOGICAL AND ECONOMIC DEVELOPMENT OF ECONOMY
Baltic Journal on Sustainability
2009
15(3): 395–417

NANOTECHNOLOGY AND SOCIOPOLITICAL MODERNITY IN DEVELOPING COUNTRIES; CASE STUDY OF IRAN[1]

Sepehr Ghazinoory[1], Reza Ghazinouri[2]

[1] Tarbiat Modares University, Department of Information Technology Management, Tehran, Iran
E-mail: [1]ghazinoory@modares.ac.ir

[2] University of Tehran, Department of Social Science, Tehran, Iran
E-mail: [2]ghazinouri@gmail.com

Received 24 August 2008; accepted 20 August 2009

Abstract. What we must keep in mind is that although nanotechnology is an emerging and high technology, it is still technology or, in other words, it has an instrumental nature and in order to study its effect on societies we have to consider the role of instruments' evolution in societies and study nanotechnology as the most recent part of this trend. In this article we study the nature of modern technologies, role of technology based economy on different social and political aspects of developing countries; we have a review on the concept of social and political modernity and describe how development of nanotechnology will accelerate those countries' modernization from social and political point of view in addition to modernizing their economy. So this paper is a cross-disciplinary study between nanotechnology and social sciences. There are two different scenarios about the future of nanotechnology. One is the proof of radical nanotechnology and the other is the acceptance of the claim that nanotechnology is only an enabling technology. In the present paper, we studied the effects of both scenarios. The obstacles to modernity in Iran and potential effect of nanotechnology on them are studied as a case study.

Keywords: nanotechnology, modernity, Iran, knowledge based economy, commodity dependency, socio-technical system, developing countries.

Reference to this paper should be made as follows: Ghazinoory, S.; Ghazinouri, R. 2009. Nanotechnology and sociopolitical modernity in developing countries; case study of Iran, *Technological and Economic Development of Economy* 15(3): 395–417.

[1] We are thankful to the Managing Editor, Dr Jonas Saparauskas and the esteemed referees for their critical evaluation of the paper and valuable comments and suggestions.

ISSN 1392-8619 print/ISSN 1822-3613 online
doi: 10.3846/1392-8619.2009.15.395-417
http://www.tede.vgtu.lt

1. Introduction

There may be little doubt about the idea that technological development played the most important role in societies' and countries' development in the past two or three centuries. As a good example of this role, Crow and Sarewitz (2001) believe that the evolution of agricultural technology for a single cash crop is indissolubly bound to the ongoing struggle to overcome the U.S. legacy of slavery, segregation, and bigotry.

The above sentence is a clear example of technology evolution effect on society which the major part of this article is relied on. It should be mentioned that in this article we particularly focus on nanotechnology and its special features in comparison other technologies. All different points of view about relationships between technology and society with all their differences can be logically divided into three main theories: technological determinism, social constructivism of technology and co-evolution of society and technology.

We speak more about the co-evolution of society and technology later in the article as most of social scientists (such as: Rosenkopf & Tushman 1994) believe that co-evolution of the technological development and social phenomena seems to be more realistic.

While philosophers and social theorists asserted the "technological shaping of society", historians and sociologist countered with the "social shaping of technology".

Since both of these shaping types are accepted, we believe in interaction between technology and society, but as it is clear from the title of this article, our focus is more on technologies' effects on society than the role of society in the shaping of technology.

We studied the consequences of new technologies (especially nanotechnology) on modernity in developing countries, particularly Iran and for this purpose, we briefly reviewed the related concepts and the issue background; then we tried to explain the nanotechnology effecting mechanisms for creating a change in Iran society.

What is critical to be explained about this article is that because of numerous studied concepts the complete presentation of existing literature was impossible.

2. The nature of technology and modern technology

When talking about the nature or essence of something (no matter what), we have to use philosophy, and the philosophy language and technology is not an exception, so arriving to the field of philosophy of technology to some degree is inevitable.

As philosophy of technology as a coherent field of research does not yet exist, we can not present a clear and completely accepted definition of technology; but, as expressed in Routledge Encyclopedia of Philosophy (1998), the concept deals with the nature of technology and its effects on human life and society. The subject covers studies from almost every branch of thinking in philosophy and deals with a great variety of topics because of a lack of consensus about the primary meaning of the term 'technology', which may, among others, refer to a collection of artifacts, a form of human action, a form of knowledge or a social process.

What is essential to be clarified about the essence of technology is that technology is not equivalent to the essence of technology. When we are seeking for the essence of a "tree," we

have to become aware that the one pervading every tree, as tree, is not itself a tree that can be encountered among all the other trees.

What is (the essence of) technology? In philosophical-anthropological studies, the starting point for answering this question is the human being and its place in and relation to nature. The human being is considered to be a defective animal that is dependent on technology for its survival; technology becomes the substitute for biological shortcomings and is therefore determined to a large degree by the nature of these shortcomings (Heidegger 1977). As it is clear, he and his proponents give the major role in definition of technology to human factor. This idea is exactly opposite to most of technologists that assume the technology as something only technical or embodied innovations.

Technology may be embodied in the form of capital goods, such as machinery, equipment and physical structures; or it may be disembodied in such forms as industrial property rights, unpatented know-how, management and organization and design and operating instructions for production systems (UNCTC 1985).

Another controversial issue about the nature of technology is about its neutrality or non neutrality. Some proponents of technology neutrality claim that technologist and engineers should not get involved in social, political and ethical issues of technology and the user must be concerned about technology consequences as technology is a neutral phenomenon and naturally does not have any tension towards good or bad and its goodness or badness is completely user-based. For example Anderson & Crocca (1993) believe that "Even though engineers are changing the customer's work practice, they need to avoid interfering with the social and political dynamics that characterize that workplace".

Routledge Encyclopedia of Philosophy (1998) explains the discussion this way: "Another issue in this field concerns the claim that technology itself, as a system of means, is ethically neutral. Arguments against the neutrality thesis attempt to show that the conception of technology as a mere system of means is inadequate, because its impact on human life stretches much further: it replaces the natural with an artificial environment".

It seems that proponents of technology neutrality are outnumbered because most of authors are against this idea. Heidegger and Geels are two examples of these theorists.

Heidegger (1977) considers such a conception of technology very dangerous: "Everywhere we remain unfree and chained to technology, whether we passionately affirm or deny it. But we are delivered over to it. In the worst possible way when we regard it as something neutral; for this conception of it, to which today we particularly like to do homage, makes us utterly blind to the essence of technology".

Or more recently, Geels (2004) writes: "Human beings in modern societies do not live in a biotope, but in a technotope. We are surrounded by technologies and material contexts, ranging from buildings, roads, elevators, appliances, etc. These technologies are not only neutral instruments, but also shape our perceptions, behavioral patterns and activities. Socio-technical systems thus form a structuring context for human action. The difference between baboons and human beings is not just that the latter have more rules which structure social interactions, but also that they interact in a huge technical context.

After this discussion about the nature of technology, now we have to ask ourselves what modern technology is and what the distinction between technology (in general form

whether modern or non-modern) and modern technology is. The most believed idea about the distinction factor between the technology and modern technology is that the latter one is science based and it has a strong mutual relationship with science.

Modern technology and science, however, have merged to such a degree that even the demarcation between them has become problematic. Modern technology is science-based (and modern sciences, technology-based) and alongside the traditional natural sciences engineering sciences have established themselves. The so-called 'scientification of technology' is generally considered to be the characteristic feature of modern technology that is directly related to its prominent role in society.

This has directed attention to the problem of the relation between science and technology and how science has altered the nature of technology.

As Heidegger (1977) expresses in one of the most important contemplations about technology, it is said that modern technology is something incomparably different from all earlier technologies because it is based on modern physics as an exact science. But the establishing of this mutual relationship between technology and physics is more correct.

The distinction between science and technology also begins to lose its relevance in practice, even if in principle it is still possible to distinguish the two (Webster 1991).

Although in all these authors' ideas mutual relationship between modern science and modern technology is clear, but developing countries' policy makers often ignore this point and try to transfer the modern technology and modernize their economy. But as these countries lack needed science and appropriate social context, not all components of technology will be transferred. What is transferred is just technology's hardware, and as a result it will neither create added value, nor social modernism.

The policy makers of developing countries should realize that not only modern technologies are based on science, but also the modern science can only be developed in laboratories based on modern technology. Lacking correct understanding of technology nature and its relationship with science, society and economy among developing countries' policy makers and even scientists, results in the waste of the huge costs they expend to become modern industrialized countries.

3. Knowledge-based economy and the essence of economy in developing countries

3.1. Knowledge-based economy

In the previous section, we explained the mutual and close relationship between modern science and modern technology to a degree that they cannot be distinguished easily. Now we take a further step and say that both science and technology are two different forms of knowledge that can be named as scientific knowledge and technological knowledge.

Difference in basic concepts for interpreting and evaluating knowledge claims strongly supports the idea that two different forms of knowledge (and of rationality) are involved in science and technology (Routledge Encyclopedia of Philosophy 1998).

What is called Knowledge-based economy is completely relied on these two forms of knowledge and, to tell the truth, more directly on the technological knowledge, because it

is more practical and efficiency, effectiveness, and other criteria like durability, costs, manufacturability, safety and utility that are economic concepts are key notions in the structure of thinking in technology. In this section we have a review on the concept of Knowledge-based economy and compare it with what is going on in developing countries economy.

By the end of the twentieth century, the de-materialization of the economy had advanced to the point where 79 percent of jobs and 76 percent of the GNP in the USA were in the service sector. Europe and Japan lagged only slightly behind. (Contractor & Lorange 2002).

The main processes of these kinds of economies are not based on materials de-materialization as the most important trend in the new economy, changed the main activities. Experts believe that the core activity of a knowledge-based economy is R&D and innovation.

Trends in business R&D over the 1990s were discussed, as well as patents, high-tech trade, changes in research activities like new forms of financing (venture capital) and increased collaboration (Godin 2004). Now (these factors) are widely grouped under the "knowledge-based economy" concept.

An economy based on knowledge favors customization, flexibility, rapid response and dis-internalization or deconstruction of the value chain.

In this age of the knowledge-based economy, the lifespan cycle of the merchandise is extremely short (Hsu *et al.* 2008).

Because of this character of knowledge-based economy, it is obvious that developing countries whose economies rely on determined commodities will face complicated problems in a globalized knowledge-based economy.

Firms like Microsoft (that are symbols of new knowledge based economy) have most of their value in "knowledge capital", embedded in its personnel, its organization, patents, copyrights, brand value and so on (Godin 2004).

Knowledge-based economy is the distinctive feature of developed countries and is based mainly on modern technologies. In other words, developed countries reached both modern technologies and sociopolitical modernity. These two factors continuously intensify each other. It means that modern science and technologies extend and deepen sociopolitical and economic modernity. Modernity works as an appropriate infrastructure for modern science and technologies. As we discussed in 3.2, developing countries suffer from a reverse cycle. Lacking or weakness of each of these two factors is an obstacle for the other one.

3.2. The essence of economy in developing countries

Commodity production is the mainstay of the economy in most developing countries. According to ETC Group (2005: 11), commodity dependence is measured by the share of the three leading commodities in a given country's total exports. The bigger the share, the more dependent the country is. Commodity dependence and poverty are closely intertwined. Commodities provide the primary source of income for the South's rural poor. According to the Common Fund for Commodities, out of the two and a half billion people engaged in agriculture in developing countries, an estimated one billion derive a significant part of their income from the production of export commodities. The challenges posed by commodity dependence are myriad and complex.

3.3. Level of commodity concentration

Commodity concentration is the value of a nation's most important export commodity measured as a percentage of its total exports. It shows the degree that a country is relying on a single commodity and is vulnerable to market fluctuations for their export earnings (Sandra *et al.* 2004).

Table 1 shows the share of three leading commodities in total exports by most commodity-dependent developing countries in percentages:

Table 1. Leading commodities in commodity dependent developing countries (ETC Group 2005)

Rank	Country	Percent	Three leading commodities
1	Solomon Islands	97.06	Wood non-coniferous, Fishery commodities, Palm oil
2	Brunei Darussalam	95.87	Fuels, Poultry Meat, Cabbages
3	Botswana	94.59	Diamonds sorted, Bovine Meat, Hides and Skins
4	Niger	94.00	Uranium, Live Animals, Tobacco
5	Iraq	93.43	Fuels, Dates, Hides and Skins
6	Kuwait	93.10	Fuels, Sulphur, Fruit Juices.
7	Libyan Arab Jamahiriya	92.98	Fuels, Fishery commodities, Hides and Skins
8	Greenland	92.83	Fishery commodities, Fuels, Hides and Skins
9	Gabon	91.81	Fuels, Wood non-coniferous, Manganese ore
10	Turkmenistan	91.56	Fuels, Cotton Lint, Wine
11	Congo	91.17	Fuels, Wood non-coniferous, Sugar
12	Kiribati	89.28	Fishery commodities, Copra, Crude Materials (incl. Flowers)
13	Algeria	88.99	Fuels, Nat. Ca Phosphate, Dates
14	Saudi Arabia	88.95	Fuels, Sulphur, Dairy Products + Eggs
15	Netherlands Antilles	88.91	Fuels, Rice, Sugar
16	Dem. Rep. of the Congo	88.88	Diamonds sorted, Coffee Green + Roasted, Wood Non- Coniferous
17	Suriname	88.63	Alumina (AL oxide, hydroxide), Rice, Fuels
18	Nigeria	86.94	Fuels, Cocoa + products, Natural Rubber
19	Comoros	86.75	Vanilla, Essential Oils, Cloves, Whole + Stems
20	Burundi	86.57	Coffee Green + Roasted, Tea, Sugar,
21	Equatorial Guinea	83.88	Fuels, Wood non-coniferous, Cocoa + products
22	Yemen	83.65	Fuels, Fishery commodities, Coffee Green + Roasted
23	Guinea-Bissau	81.96	Nuts, Fishery commodities, Cotton Lint
24	Iran, Islamic Republic of	81.58	Fuels, Nuts, Oil of Soya Beans
25	Oman	81.56	Fuels, Tobacco, Fishery commodities
26	Sao Tome and Principe	81.32	Cocoa + products, Fishery commodities, Coffee Green + Roasted

Continuation of **Table 1**

Rank	Country	Percent	Three leading commodities
27	Venezuela	81.32	Fuels, Iron ore and concentrates, Tobacco
28	Ethiopia	80.28	Coffee Green + Roasted, Hides and Skins, Sesame Seed
29	Angola	79.88	Fuels, diamonds sorted, Coffee Green + Roasted
30	Qatar	78.72	Fuels, Live Animals, Sulphur
31	Ecuador	77.75	Fuels, Bananas, Fishery commodities
32	Jamaica	77.61	Alumina (AL oxide ,hydroxide), Sugar, , Bauxite
33	Malawi	76.52	Tobacco, Tea, Sugar
34	Mauritania	75.60	Iron ore and concentrates, Fishery commodities, Fuels
35	Maldives	74.92	Fishery commodities, Wood non-coniferous, Copra
36	Central African Republic	70.00	Diamonds sorted, Wood non-coniferous, Cotton Lint
37	Cuba	69.49	Sugar, Tobacco, Fishery commodities
38	Uganda	68.37	Coffee Green + Roasted, Fishery commodities, Crude Materials (inc. Flowers)
39	Syrian Arab Republic	68.20	Fuels, Cotton Lint, Tomatoes
40	St. Vincent & Grenadines	67.90	Bananas, Wheat + Flour, Rice
41	Zambia	67.83	Refined Copper, Sugar, Cotton Lint
42	Bahrain	67.81	Fuels, Iron ore and concentrates, Palm oil

As we see in Table 1, developing countries' exports are seriously dependent on several specific commodities and most of these commodities are exported in raw form. These kinds of commodities are of little added value and are losing their prices too. In other words, if we ignore changes in global prices level, developing countries' exporting goods prices are continuously decreasing and so their income. In addition, new technologies and products from developed countries are rapidly entering markets and developing countries have to buy them (to prevent widening the technological and economic gap). Therefore, developing countries must try to export diversified and high added value products and for this purpose they have to use new technologies. The problem is that these countries lake a suitable context for adoption, diffusion and application of these technologies and therefore, their policy makers will encounter complicated problems.

Another noteworthy point about commodity dependent developing countries is distribution of wealth in this kind of countries. Most important share of wealth and accordingly an important part of socio-political power and authority in these countries are in the hands of central governments and traditional owners of assets most of whom are traditional and religious people who are not well educated and many of them do not believe in the necessities of modern societies such as human rights. We will discuss this issue later in the article.

4. Sociopolitical modernization

4.1. Modernization and postmodernization

Modernity and Modernization have lots of different meanings and definitions in many different references. We are not to explain all of them here but try to show the trajectory of modernity and modernization theories. Now we explain the classic modernization theory and explain its criticisms that led to newer theories like Postmodernization and study the relationship between technological and economic development and modernity.

Economic, cultural and political changes go together in coherent patterns that are changing the world in predictable ways. This has been the central claim of modernization theory, from Karl Marx to Max Weber to Daniel Bell.

Industrialization, for example, tends to bring increasing urbanization, growing occupational specialization, and higher level of formal education in any society that undertakes it. These are core elements of a trajectory that is generally called modernization. This trajectory also tends to bring less obvious but equally important long-term consequences, such as rising levels of mass political participation (Ingheart 1997).

Economic development is linked with a syndrome of changes that include not only industrialization, but also urbanization, mass education, occupational specialization, bureaucratization, and communications development, which in turn are linked with still broader cultural, social and political changes.

That is, the world is on a particular Eurocentric path of economic and social change engendered by the ideals of Enlightenment; the West arrived there first, and the rest is expected to reach there eventually through catching up a process (Parayil 2003).

But this primary version of modernity theory has encountered with lots of criticisms almost since 1950s and 1960s. Of course a large part of these criticisms were answered by later modernity theorists that accepted deficits in this theory but insisted on the central claim and core. The criticisms were directed against its alleged eurocentrism, its gross exaggeration of the homogeneity of both western and non-western societies, the methodological silencing of contradictions within modern societies and its optimistic outlook (Flitner & Heins 2002).

After these criticisms about modernization theory and the maturity of modernity in developed and industrial societies, a new trend was observed by lots of social scientists and researchers called Postmodernization.

Although the common point of view is that these two trends are contradictory, Postmodernization is continuation of most of modernization factors and a change in some of them.

Postmodernization continues some of the trends launched by modernization, particularly the processes of specialization, democratization, and individualization. Two important aspects in the postmodern shift are growing emphasis on individual freedom and rejection of bureaucratic authority.

4.2. Technological and economic development and modernity

Above we studied some explanations, definitions and trends of modernity and postmodernity and as it was clear most of them were related to Technological and economic development

but now we are going to study some evidences that more directly connected this concepts and studied the effects of Technological and economic development on modernity. For example, Moore (1963) expressed that: What is involved in modernization is a total transformation of a traditional or pre-modern society into the types of technology and associated social organization that characterize the advanced economically prosperous and relatively politically stable nations of the western world.

Or, in another section of the same book the author claims that.

The process of modernization's most commonly approached in terms of economic development. This has a high but not absolute validity, for it's possible to find situation in which the immediate and short-run priority is accorded to the state, the school or the rural community, yet rising per capita levels of living have a kind of unquestioned value in developing countries and economic development has a rather important instrumental value for most of the other reforms that may be ultimately justified on other grounds.

Or in Ingheart (1997) after confirming the above mentioned relationship, the quality of such a relationship is questioned:

Does economic change cause cultural and political change or does it work in the opposite direction?

For some recent modernization theorists such as Bell (1976) transition from industrial economy to knowledge-based economy is the indicator of postmodernization and postindustrialization. For Bell, the crucial sign in the coming of "postindustrial society" is reached when a greater part of workforce is in the tertiary sector of economy, producing neither row materials, nor manufactured goods, but services (Ingheart 1997: 10). This leads to massive increase of formal education, driven by the need for an increasingly skilled and specialized work force.

Of course, there were lots of criticisms about these casual links in both ways (the effects of Technological and economic development on modernity and vice versa) but most of them were not serious and received good answers by different social scientists. Then, Ingheart (1997: 101) answers to one of such criticisms:

Coherent cultural patterns exist, and they are linked with economic and technological development. For example, industrialization was accomplished by democratization in western history. But some observers argue that, since some Arabic countries such as Saudi Arabia and Libya have grown rich without democratization, there is no linkage between economic development and democratization. This argument ignores the fact that modernization is not just possession of large oil deposits: it is a syndrome of cultural, economic and technological changes closely linked with industrialization- a syndrome that Saudi Arabia and Libya have not experienced, and which does tend to be linked with democratization.

A broad syndrome of changes has been linked with modern economic development. These changes include urbanization, industrialization, occupational specialization, mass formal education, development of mass media, democratization, individualization, the rise of entrepreneurs and entrepreneurial motivations, bureaucratization, the mass production assembly line, and the emergence of modern state.

Of course other aspects of modernizations should be considered:

As explained before, postmodernization is not contradictory to modernization but it is better to say that postmodernity is a revised version of modernity. If we want to know what conditions developing countries are going to reach by nanotechnology, we have to consider these revisions. Modernization theory is based on industrialization era situation and we are looking for the situation of postindustrialization era and societies with knowledge based economy.

After summarizing the above discussions and studying revisions of modernity theory, we recognized following mentioned trends as we think they are the ones that developing countries can be hopeful to reach by transition to an economy based on knowledge and technologies and specially nanotechnology:

1) democratization,
2) mass formal education,
3) urbanization,
4) development of mass media,
5) individual autonomy, self-expression, and free choice,
6) emergence of modern state,
7) powerful mass demands for democracy,
8) mass political participation,
9) occupational specialization,
10) the rise of entrepreneurs and entrepreneurial motivations,
11) change in structure of workforce pro service sector,
12) rationalization.

It must be mentioned that it is impossible to determine priority of above-mentioned trends so there is no order in their ranking.

As we explained, trends like bureaucratization and the extension of mass production assembly lines are omitted because of the postindustrial era nature.

5. Nanotechnology as technological convergence and its different scenarios

As stated in introduction, all kinds of technologies and applied sciences have sociopolitical consequences but the situation of nanotechnology is different because Nanotechnology refers, not to one discrete branch of applied science but, to a set of diverse techniques that involve a variety of scientific disciplines.

Of course, effects of such a technology will be broader and more complex. It seems that most of technology researchers confirmed such a convergence. If we try to see this issue from a more technical point of view we have to explain that as nano-scale manipulations are now possible and, as the basic components of both living and non-living matter exist on the nano-scale, it is now possible to converge technologies (and to converge scientific disciplines) to an unprecedented degree. Technological convergence, enabled by nanotechnology and its tools, can involve biology and biotechnology, physics, material sciences, chemistry, cognitive sciences, informatics, applied mathematics, electronics and robotics, among others (ETC Group 2005).

This relationship between nanotechnology and other technologies like biotechnology and information technology is expressed to reach an extent that is hard to draw clear boundaries between nanotechnology and others in terms of identifying its development. Technology convergence has been identified as a universal trend; and, these technologies are very interactive among themselves. It is a global trend that technologies do not only advance within their sole field, but also work in interaction with other types of technology (Kyungchee Choi Ewha Womans University 2003).

Much of the impact of nanotechnology will occur through its convergence with other fields, especially biotechnology, information technology, and new technologies based on cognitive science. So it is natural that most of nanotechnology effecting mechanisms (that will be discussed further in the article) will occur through other technologies and as a possibility, not all the people in a society will realize the real source of changes.

Almost since the creation of the word "nanotechnology", there were two different scenarios about its future. The dominant scenario was that nanotechnology is an enabling technology and it helps other technologies and does not have any direct application. This approach is called top-down manufacturing and proponents of this scenario are sometimes called nano-realists. What has come true until now are all gained by this side of the coin (Hodge & Bowman 2006).

Fig. 1 shows the nanotechnology (as an enabling technology) application in this scenario.

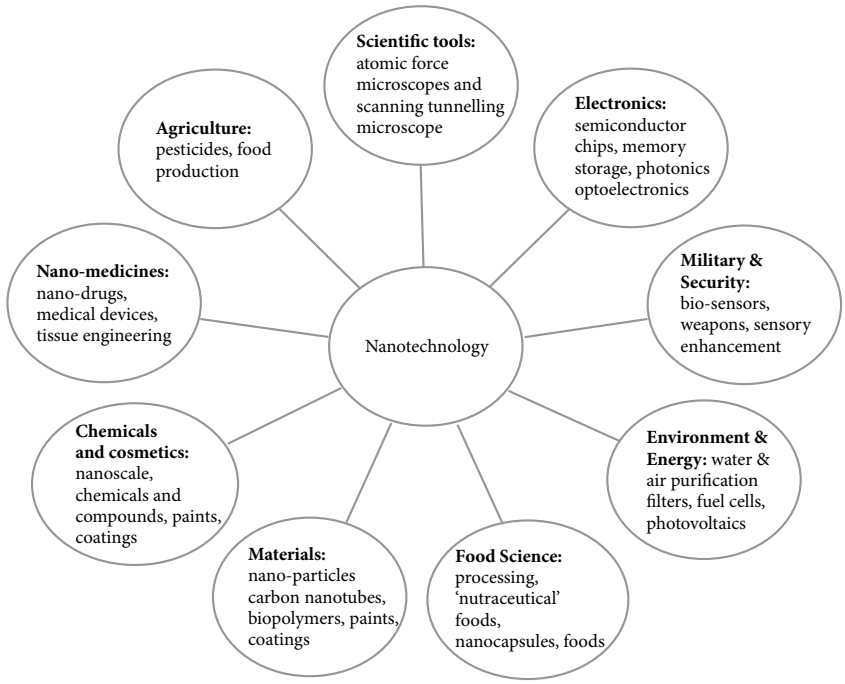

Fig. 1. Nanotechnology applications (Hodge & Bowman 2006)

Another scenario that caused lots of criticisms and skepticism is radical nanotechnology, Molecular Manufacturing, Molecular Nanotechnology or bottom-up manufacturing.

Now we take a look at its definitions, explanations and criticisms in some scientific articles: Molecular Nanotechnology is the method of creating products by means of molecular machinery, allowing molecule-by-molecule control of products and by-products through positional chemical synthesis (ETC Group 2005).

At the nanoscale level properties of traditional materials change as the behaviors of surfaces start to dominate the behavior of bulk materials. Bottom-up technology, often referred to as molecular nanotechnology (Arnall & Parr 2005).

The idea of atom-by-atom construction was first put forth by Nobel Prize winning physicist, Richard Feynman. Feynman suggested that devices and materials could someday be fabricated to atomic specifications, but for this to happen, a new class of miniaturized instrumentation would be needed to manipulate and measure the properties of these small "nano-structures".

In the mid-1980s, Dr. Eric Drexler, a researcher concerned with emerging technologies and their consequences for the future, introduced the term 'nanotechnology' to describe atomically precise molecular manufacturing systems and their products. The possible developments he has identified include molecular manufacturing systems able to construct computers smaller than living cells, devices able to repair cells, diamond-based structural materials, and additional molecular manufacturing systems.

The first person who spoke about radical nanotechnology was Eric Drexler in his book "Engines of creation".

Now we will have a brief review on his theory and then we present our schematic model for different scenarios of nanotechnology evolution in Fig. 2.

In short, with molecular technology and technical AI we will compile complete, molecular-level descriptions of healthy tissue, and we will build machines able to enter cells and to sense and modify their structures.

The ancient style of technology that led from flint chips to silicon chips handles atoms and molecules in bulk; call it bulk technology. The new technology will handle individual atoms and molecules with control and precision; call it molecular technology. It will change our world in more ways than we can imagine.

As assemblers will let us place atoms in, they will let us build almost anything that the laws of nature allow to exist. In particular, they will let us build almost anything we can design – including more assemblers. The consequences of this will be profound, because our crude tools have let us explore only a small part of the range of possibilities that natural law permits (Drexler 1986: 19).

Although these two scenarios are different in the way and speed of effecting modernity in society, but there is no doubt about the deep effects of both of them. Of course the legal and standard system for each of the scenarios will be different. Fig. 2 shows that nanotechnology can result in a modern society through one of these scenarios (or even both of them).

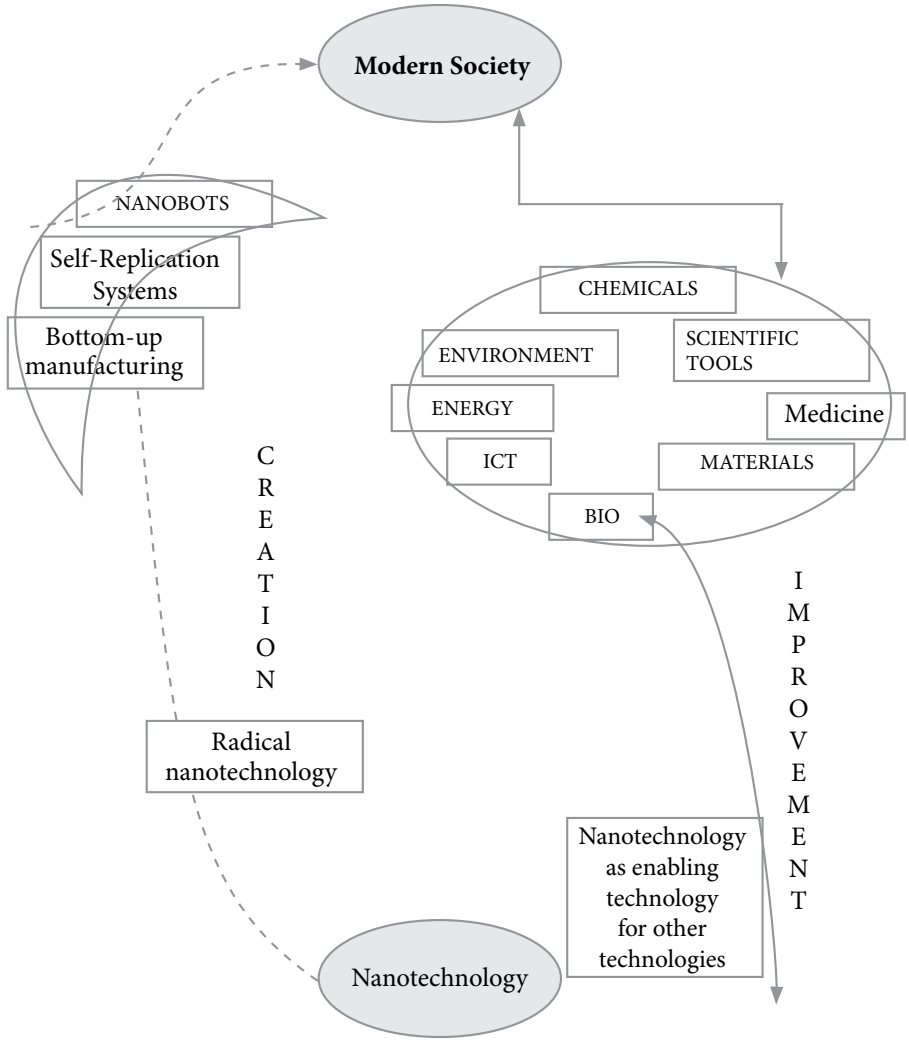

Fig. 2. Different nanotechnology scenarios (self-compilation)

6. Transition to nano socio-technical system

As we mentioned in the introduction, we believe in co-evolution of the technological development and social phenomena. But studying such a complicated relationship is impossible without a precise analytical framework. Socio-Technical System seems to be such a framework. But the problem is that the main application of this tool was for analyzing system innovations or for studying organizations' behavior. But, in this article we tried to use it in macro-level of countries' social and political systems.

First in this section, we briefly take a look on socio-technical system literature that includes transitions from one system to another, stability, instability, etc., and then we speak about possible changes in developing countries' social and political conditions in case of reaching nanotechnology-based economy. The main idea of this article is that if technical part of the socio-technical system of developing countries changes from backward industrial companies and exportation of raw materials to nanotechnology as the convergence of modern technologies, the socio-political part and cultural meaning around will become modern.

6.1. Socio-technical system

Socio-technical system is considered as a generalized model of the dimensions of social and technical systems.

Human and organizational outcomes could only be understood when social, psychological, environmental, and technological systems are assessed as a whole. This perspective assumes that organizations are "made up of people (the social system) using tools, techniques and knowledge (the technical system)" (Majchrzak & Borys 2001).

Socio-technical systems consist of technology, regulation, user practices and markets, cultural meaning, infrastructure, maintenance networks, supply networks.

Human beings in modern societies do not live in a biotope, but in a technotope. These technologies are not only neutral instruments, but also shape our perceptions, behavioral patterns and activities.

Socio-technical systems thus form a structuring context for human action (Fig. 3).

Above there are socio-technical systems distinguished on the one hand and human actors and the social groups on the other hand. But human actors are not entirely free to act as they want. Their perceptions and activities are coordinated (but not determined) by institutions and rules. Socio-technical systems do not function autonomously, but are the outcome of the activities of human actors. Human actors are embedded in social groups which share certain characteristics, e.g. certain roles, responsibilities, norms, perceptions (Fig. 4).

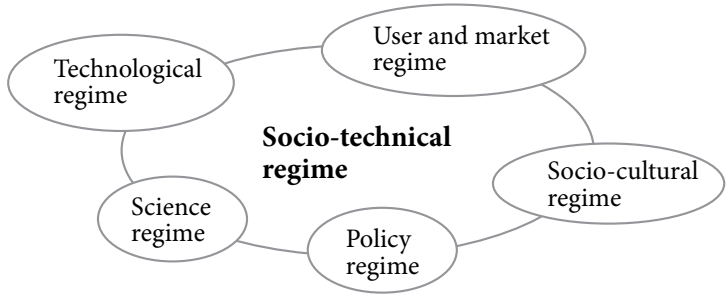

Fig. 3. Meta-coordination through socio-technical regimes (Geels 2004)

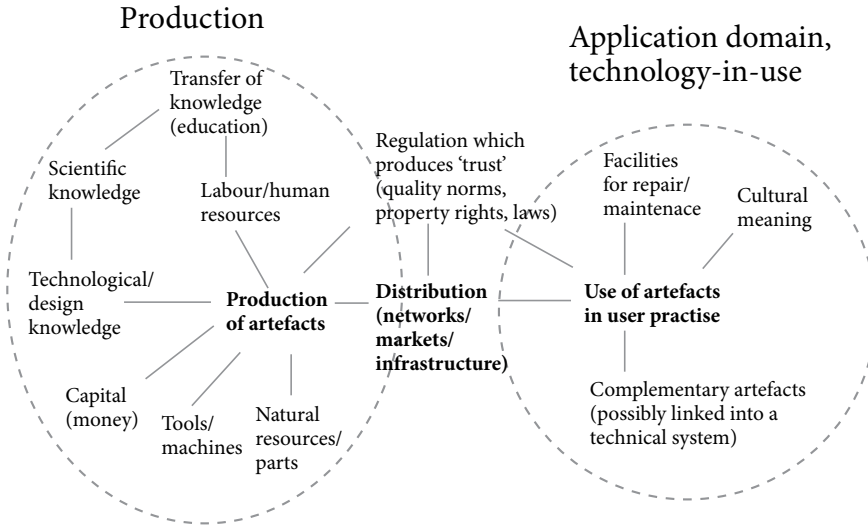

Fig. 4. The basic elements and resources of socio-technical systems (Geels 2004)

Socio-technical systems, rules and social groups provide stability through different mechanisms. The three interrelated concepts of ST-systems, rules and social groups can be used to group their insights and highlight different aspects of stability.

First, rules and regimes provide stability by guiding perceptions and actions.

Cognitive rules: cognitive routines make engineers and designers look in particular directions and not in others. Normative rules: social and organizational networks are stabilized by mutual role perceptions and expectations of proper behaviour.

Regulative and formal rules: established systems may be stabilized by legally binding contracts.

A fourth type of stability is the alignment between rules. It is difficult to change one rule, without altering others.

Second, actors and organizations are embedded in interdependent networks and mutual dependencies which contribute to stability. Third, socio-technical systems, in particular the artefacts and material networks, have a certain 'hardness', which makes them difficult to change. Once certain material structures or technical systems, such as nuclear re-processing plants, have been created, they are not easily abandoned, and almost acquire logic of their own.

Complementarities between components and sub-systems are an important source of inertia in complex technologies and systems.

To understand transitions from one system to another the notions of tensions and misalignment are useful. The different regimes have internal dynamics, which generate fluctuations and variations, (e.g. political cycles, business cycles, technological trajectories, cultural movements and hypes, lifecycles of industries).

6.2. About the transition of developing countries

Institutions, regulations and collective beliefs exist in order to ensure certain equilibrium in the social distribution of benefits and risks. But innovation is by definition something that challenges habits, received ideas and traditional values. Some regulations may run counter the spread of a new technical system. Other technologies may upset the belief and value of a group or a whole society.

In section 3, we gave explanation on commodity dependent economies of developing countries and the quality of wealth distribution in such countries. We said that the most important share of wealth and accordingly an important part of socio-political power and authority in these countries are in the hands of central governments and traditional owners. In developed countries, the important share of wealth is in the hands of managers and owners of new industries and technologies that most of them are well-educated and modern people. In countries like Iran, due to the lack of formed and strong technology-based industries and because its economy is highly related to oil exporting income, another important share of wealth is in the hands of traditional capitalists whose wealth is gained through exporting and selling commodities.

This class has a very close relationship with political managers and so is preventing modernization in government structure. If nanotechnology can change this situation and change the developing countries economy from economies based on exportation of commodities and raw materials to economies based on modern technologies, the quality of wealth distribution will change pro educated people and scientists and these groups of people will gain the power in order to form modern social and political institutions.

About developing countries whose wealth is based on exportation of crude oil... It is good to explain that development of nanotechnology and reaching what is called nano-energy will stop mass demand for oil in the world and this kind of economies will stop working, so these countries' government will feel the need for people taxes and therefore might their totalitarian approach to their people.

7. Nanotechnology and sociopolitical modernity in Iran

The government's attention to nanotechnology in Iran started in 2001, when then Iranian President Mohammad Khatami made Technology Cooperation Office (TCO) responsible for coordination of developmental activities for nanotechnology in the country. In 2003, after extensive studies and analysis, TCO recommended creation of a council and was given the task of defining a direction for nanotechnology development in Iran (Ghazinoory *et al.* 2009a).

Additionally, the TCO concluded that nanotechnology development in Iran requires national initiative, proposed the National Iranian Nanotechnology Initiative Program (NINI) that was subsequently approved by Iranian cabinet in July 2005 (Ghazinoory *et al.* 2009b).

In this section, we study the effects and implications of nanotechnology evolution on Iran sociopolitical situation as a developing country. For this purpose, first we must take a look at Iran's social, political and economic background and its current conditions (Ghazinoory & Heydari 2008). But as this is a much extended topic, we tried to cover it very briefly. First, a

table is developed to show the contemporary Iran political background, then we discussed a little about democracy in Iran and then reviewed the important obstacles to modernity. The latter part is trying to show how nanotechnology will help to remove these barriers.

7.1. Contemporary Iran political background

Table 2 is somehow the history of modernity in Iran and is going to illustrate the zigzag way of modernity progress. As it is shown in that table, along the 20th century, there were several reformative and revolutionary movements through democracy and modernity which the most important ones happened in 1906,1909,1951,1979 & 1997. But the movements' life cycles were too short usually.

Table 2. Contemporary Iran political background (Gheissari, Nasr 2006)

1794–1925	Qajar dynasty
1906	Constitutional Revolution; Iran is granted a parliament
1907	Anglo-Russian agreement dividing Iran into spheres of influence
1908	Bombardment of the Parliament and restoration of autocracy
1909	The Anglo-Persian Oil Company is founded
1909	Regaining of Tehran by the constitutionalist forces and restoration of the constitutional government
1910–1911	Occupation of northern Iran by Russian forces and reversal of constitutionalists' reforms
1914–1918	First World War; Iran declares neutrality
1919	Anglo-Persian Agreement, giving the British broad political, economic, and military control over Iran, meets with nationalist opposition and is not ratified by the Parliament
1921	Military commander Reza Khan stages a coup and overthrows the government. Reza Khan becomes Army Commander, and subsequently Minister of War
1925–1941	Reign of Reza Shah Pahlavi: formation of a centralized bureaucratic state, initiating broad range of civil and legal reforms and educational, industrial, and economic modernization
1927	European dress codes imposed
1936	Abolition of the veil
1939–1945	Second World War; Iran declares neutrality
1941	Allied invasion and occupation of Iran leads to Reza Shah's abdication in favor of his son, Mohammad-Reza Pahlavi
1951	Popular campaign in favor of the renegotiation of Anglo-Iranian oil agreement. Mohammad Mosaddeq, leading the call for nationalization of oil, becomes prime minister. Oil nationalization bill is ratified by the Parliament
1953	A military coup with British and American backing overthrows Mosaddeq and his National Front government. General Fazlollah Zahedi is appointed prime minister by the Shah
1963	The Shah launches wide-ranging social and economic reforms known as the "White Revolution" about women and land reform
1964–1971	Rapid industrialization of the Iranian economy: Iran achieves some of the highest manufacturing growth rates in the Third World. Modernization of state institutions and the armed forces and centralization of development planning

Continuation of **Table 2**

1978	Massive demonstrations against the Shah during the Islamic ceremonies
1979	The Shah leaves Iran because of Islamic revolution
1979	Imam Khomeini returns to Iran and appoints Mehdi Bazargan prime minister of the Provisional Government. Overthrow of the Pahlavi dynasty and the end of the monarchy
1980	Iraq invades Iran; beginning of an eight-year war
1988	Iran and Iraq accept a UN resolution for a cease-fire
1989	Imam Khomeini dies. Ayatollah Khamenei is appointed as Supreme Leader
1997	Mohammad Khatami is elected president
1997–2005	Presidency of Khatami: attempted political and cultural reforms, emphasis on civil society institutions and dialogue among civilizations, recurrent tension with the conservatives, conservative consolidation
2002	Russian technicians begin construction of Iran's first nuclear reactor at Bushehr despite strong objections from the United States
2005	Mahmoud Ahmadinejad, Tehran's conservative mayor, is elected president
2006	IAEA votes to refer Iran to the UN Security Council over its nuclear program

7.2. Cultural obstacles to modernity and democracy in Iran

The growth of modernity and foreign thoughts and western civilization's methods and institutions in Iran since the end of 19th century caused public reaction (Bashiriyeh 2003: 58).

Some public beliefs like falling into the booby trap of paranoia, Excessive cultural hostility with foreigners, deep interest in renewing old traditions, explicit and implicit belief in lowliness of women and being anti-woman in practice and folkloric political and cultural beliefs can prevent the realization of democracy in Iran (Mirsepasi 2002: 7).

In lack of the reliable information, we cannot precisely evaluate the growth of citizenship tendency, but there are implications that show empowerment and going out from outskirt process for lower social classes, even farmers and nomads that historically had terrible situation.

Field researchers are recently reporting the growth of subjectivity that is the base of citizenship tendencies (Vahdat 2003: 76).

Of course, difficult economic situation decelerated this trend, because economic problems prevent political participation for a large number of people. We will discuss this issue later.

What is important in today's Iran is the massive extension of discussions and dialogues between Iranian citizens in the society's public sphere. The more extended is the society's public sphere, the more citizens are included and people participate more enthusiastically and Iran civil society is more extended and democracy is deeper and more rooted in society (Mirsepasi 2002: 48). But shaping such a public sphere is very difficult in today's Iran.

7.3. Structure of Iran economy; a big barrier to modernity

About 85% of the export income and 54% of the public budget is provided by oil exports (Ghazinoory 2005).

One of the important features of the state in Iran is its being based on rent. Rent is a group of interests that is gained without considerable expenses and owner of that own continuous will have maneuver possibility in the political domain. A government owns continuous oil exporting income and is able to inject it into the economy own a power that a government without rent lack it (Hajjarian 2000: 165).

A large portion of Iran's economy is led by the government or affiliated companies or through public divisions under the supervision of a religious leader. The share of the private sector is between 30% and 40% (Ghazinoory & Ghazinoori 2006).

In this situation the most important reason for discriminating between different social classes is neither their relative income, nor their Common relationship with production tool but the determinant of welfare level is their relative socioeconomic position. So, social classification is dependent on relationship with government (Katouzian 1998: 133).

In other words, the powerful and rich class is clientele of the government and when there is an anti-modernity government, it is clear what kind of people will be these clienteles will be.

But there it is evident that availability of this kind of money for oil exporting countries like Iran is going to finish soon with further development of nanotechnology.

To illustrate, a disruptive effect in the energy sector might occur as a result of solar cell manufacture becoming much less expensive (Arnall & Parr 2005).

Nano-scale technology is also being employed to develop inexpensive, flexible and efficient solar cells as a source of renewable energy (ETC Group 2005).

Nanotechnology promises to achieve energy independence for major industrial nations, both from ecologically sound production of energy and from a reduction in the demand for energy caused by a host of efficiencies facilitated by nanotechnology (Roco; Bainbridge 2002).

Nanoscale-related improvements in energy technology will reduce the dependence on fossil fuels (Roco & Bainbridge 2002).

In 6.3, we extensively explained how these will change sociopolitical situation in developing countries like Iran.

7.4. Other effects of nanotechnology on sociopolitical modernity in Iran

Much of the impact of nanotechnology will occur through its convergence with other fields, especially biotechnology, information technology, and new technologies based on cognitive science (Roco & Bainbridge 2002).

Now, we analyze the impacts of nanotechnology on society through improvement of other technologies like ICT, Biotechnology and agricultural technologies. First some examples about ICT:

We already explained the importance of public sphere for democracy and the problems for shaping that, but with ICT, it is possible to have a virtual public sphere without the fear of prosecution or need for any physical place. Of course there are some places for this purpose now, but the problem is that the high price of needed devices is not affordable for majority of people in a country like Iran. One of the most important impacts of nanotechnology is

reducing the costs and prices so that most people from all social classes would become able to use such devices and it would help to shape such a Public sphere.

As we mentioned in section 3, Mass formal education is one of the important factors of modernity, but unfortunately higher education is hardly available in villages, towns and small cities, but in such a scenario, e-learning will replace the classic form of education in those regions and more people will be able to participate. We previously discussed the importance of free and mass media for removing traditional beliefs and as a factor of modernity. According to a survey in 2002 with more than 1000 questionnaires, TV is the primary news source for Iranians and is very effective on their attitudes and, as we explained before, its control is completely in the hands of state (Table 3).

Table 3. Relative distribution of population according to their most important source of the country and foreign news (Sarukhani, Mehdizadeh 2002)

Total	Internet	Talking to others	Satellite	Foreign radio channels	Newspapers	TV	Radio	Relative distribution
100	0.1	4.7	1.2	1.1	11.1	79	2.8	source of the country news
100	5.5	0.7	2.2	2	10.2	76.5	2.9	source of foreign news

One way to change this situation is mass utilization of satellite TV's. If the technology can reduce the cost and size of such devices, most of people will use them instead of IRIB (the official TV and Radio) and this will have a strong effect on their attitude.

Now, we will offer a few examples of nanotechnology effects on society through the improvement of Biotechnology and agricultural technologies. Dissatisfaction of physiological needs considered above as a barrier to the growth of citizenship tendencies. Nano-enabled improvement to agricultural technologies or green biotechnology will reduce the price of food to a degree that food will not be people's primary concern. Another issue is the people working in the villages in farms (about 35% of Iranians live in villages).

As nanotechnology improves the efficiency, it reduces the number of workers needed to produce a given level of output (Voves 2005), so the number of rural people will greatly decrease and this will weaken the base for conservatives. Of course, as stated in the 4th chapter, this process (urbanization) itself is a factor of modernity.

Certainly, these are only some examples of nanotechnology potential impacts on sociopolitical modernity which are not limited to the ones mentioned. Definitely, Iran and most of other developing countries are advancing in the route of modernity, and nanotechnology will be a catalyst and accelerator of this change.

8. Conclusion

Effective study on technology evolution effect on society without an efficient and structured approach is nearly impossible. And we searched for such an approach in this article. After explaining technology and the nature of modern technologies as well as searching for an essence for developing countries economies, we discussed what a modern society really means. Then we proposed using socio-technical system as an analytical frame work for studying co-evolution of technology and society. The main idea was that if the technical part changes from traditional to modern, the social part will probably follow. So, if the technical system of developing countries changes to nanotechnology that is the convergence of all modern technologies, we will probably see a great change in their social part through modernism.

References

Anderson, W.; Crocca, W. 1993. Engineering practice and co-development of product prototypes, *Communications of the ACM* 36(4): 49–56. doi:10.1145/153571.256015.

Arnall, A.; Parr, D. 2005. Moving the nanoscience and technology (NST) debate forwards: short-term impacts, long-term uncertainty and the social constitution, *Technology in Society* 27: 23–38. doi:10.1016/j.techsoc.2004.10.005.

Bashiriyeh, H. 2003. *Obstacles to political development in Iran* (in Farsi). Tehran, gam-e-no publications.

Bell, D. 1976. *Basic book*. Inc Publisher, New York.

Contractor, F. J.; Lorange, P. 2002. The growth of alliances in the knowledge-based economy, *International Business Review* 11: 485–502. doi:10.1016/S0969-5931(02)00021-5.

Crow, M.; Sarewitz, D. 2001. Nanotechnology and Societal Transformation, *Societal Implications of Nanoscience and Nanotechnology.* Dordrecht: Kluwer, 45–54.

Drexler, E. 1986. *Engines of creation: the coming era of nanotechnology*. Anchor Books, New York.

ETC Group. 2005. *The Potential Impacts of Nano-Scale Technologies on Commodity Markets: The Implications for Commodity Dependent Developing Countries*. Research Papers 4, South Center.

Flitner, M.; Heins, V. 2002. Modernity and life politics. Conceptualizing the biodiversity crisis, *Political Geography* 21(3): 319–340. doi:10.1016/S0962-6298(01)00046-4.

Geels, F. W. 2004. From sectoral systems of innovation to socio-technical systems: Insights about dynamics and change from sociology and institutional theory. *Research Policy* 33(6–7),*The Cultural Contradictions of Capitalism* 897–920.

Ghazinoory, S. 2005. Cleaner production in Iran: necessities and priorities, *Journal of Cleaner Production* 13(8): 755–762. doi:10.1016/j.jclepro.2004.01.010.

Ghazinoory, S.; Divsalar, A.; Soofi, A. 2009a. A new definition and framework for the development of a national technology strategy: The case of nanotechnology for Iran, *Technol. Forecast. Soc. Change* 76: 835–848. doi:10.1016/j.techfore.2008.10.004.

Ghazinoory, S.; Heydari, E. 2008. Potential Impact of Nanotechnology Development in Iran, *IEEE Technology & Society*, Winter, 37–44.

Ghazinoory, S.; Ghazinoori, S. 2006. Developing government strategies for strengthening national system of innovation, using SWOT analysis: The case of Iran, *Science and Public Policy* 33: 529–549. doi:10.3152/147154306781778759.

Ghazinoory, S.; Mirzaei, M.; Ghazinoori, S. 2009b. A model for national planning under new roles for government: case study of the National Iranian Nanotechnology Initiative, *Science and Public Policy* 36: 241–249. doi:10.3152/030234209X427095.

Gheissari, A.; Nasr, V. 2006. *Democracy in Iran: history and the quest for liberty*. Oxford University Press. doi:10.1093/0195189671.001.0001.

Godin, B. 2004. The New Economy: what the concept owes to the OECD, *Research Policy* 33: 679–690. doi:10.1016/j.respol.2003.10.006.

Hajjarian, S. 2000. *Republicanism, demystification of power* (in Farsi). Tehran, Tarh-e-no Publication.

Heidegger, M. 1977. *The question concerning technology and other essays*, trans. W. Lovitt, New York: Harper & Row.

Hodge, G. A.; Bowman, D. M. 2006. Nanotechnology: mapping the wild regulatory frontier, *Futures* 30: 1060–1073.

Hsu, G.; Lin, Y.; Wei, Z. 2008. Competition policy for technological innovation in an era of knowledge-based economy, *Knowledge-Based Systems* 21: 826–832. doi:10.1016/j.knosys.2008.03.043.

Ingheart, R. 1997. *Modernization and postmodernization cultural, economic, and political change in 43 societies*. Princeton, Princeton university press.

Katouzian, M. H. 1998. *Nine essays on Iran's historical sociology Oil & economic development* (in Farsi). Tehran, Nashre-markaz.

Kyungchee Choi Ewha Womans University. 2003. Ethical issues of nanotechnology evolution in the Asia-pacific region, the Regional Meeting on Ethics of Science and Technology. Bangkok, UNESCO, 331–374.

Majchrzak, A.; Borys, B. 2001. Generating testable socio-technical systems theory, *Journal of Engineering and Technology Management* 18(3–4): 219–240. doi:10.1016/S0923-4748(01)00035-2.

Mirsepasi, A. 2002. *Democracy or Truth* (in Farsi). Tehran Tarh-e-no Publication.

Moore, W. E. 1963. *Social Change*. New Jersey: Prentice-Hall.

Parayil, G. 2003. Mapping technological trajectories of the Green Revolution and the Gene Revolution from modernization to globalization, *Research Policy* 32(6): 971–990. doi:10.1016/S0048-7333(02)00106-3

Roco, M. C.; Bainbridge, W. S. 2002. Converging technologies for improving human performance: Integrating from the nanoscale, *Journal of Nanoparticle Research* 4(4): 281–295. doi:10.1023/A:1021152023349.

Rosenkopf, L.; Tushman, M. L. 1994. The co-evolution of technology and organization, in Baum, J. A. C. and Singh, J. V. *Evolutionary Dynamics of Organizations*. New York, Oxford University Press.

Routledge Encyclopedia of Philosophy. 1998. Philosophy of Technology. London: Routledge.

Sandra, J. M.; Nobles, J.; London, B.; Williamson, J. B. 2004. Dependency, democracy, and infant mortality: a quantitative, cross-national analysis of less developed countries, *Social Science & Medicine* 59: 321–333. doi:10.1016/j.socscimed.2003.10.022.

Sarukhani, B.; Mehdizadeh, S. 2002. *TV and modernism* (Sociology PhD thesis). Tehran, University of Tehran.

UNCTC (United Nations Centre on Transnational Corporations). 1985. Transnational corporations in world development, third survey. London. UN and Graham and Trotman.

Vahdat, F. 2003. *Iran's intellectual encounter with modernity* (in Farsi). First edition, Tehran, Qoqnus publications.

Voves, J. 2005. Trends and skill needs in the field of nanotechnology – the state of affaires in the Czech Republic in the European Context, in *International Workshop Emerging Technologies: new skill needs in the field of nanotechnology*. Stuttgart: Fraunhofer Institute for Industrial Engineering, 59–129.

Webster, A. 1991. *Science, technology and society*. First edition, London: MacMillan.

NANOTECHNOLOGIJA IR BESIVYSTANČIŲ ŠALIŲ SOCIALINIS IR POLITINIS ŠIUOLAIKIŠKUMAS: IRANO ATVEJIS

S. Ghazinoory, R. Ghazinouri

Santrauka

Nors nanotechnologija yra nauja ir pažangi technologija, ji tėra tik instrumentas. Norint įvertinti jos reikšmę visuomenei, reikia išnagrinėti panašių instrumentų raidą visuomenėse ir vertinti nanotechnologiją kaip naujausią tendenciją. Šiame straipsnyje ištirta šiuolaikinių technologijų prigimtis, technologijos vaidmuo žinių ekonomikoje skirtingais besivystančių šalių socialiniais ir politiniais periodais, apžvelgtos socialinio ir politinio šiuolaikiškumo sąvokos, apibūdinta, kaip išsivysčiusios nanotechnologijos pagreitins šalių modernizaciją socialiniu ir politiniu požiūriu be jų ekonomikos modernizavimą. Šis straipsnis yra nanotechnologijos ir socialinių mokslų tarpdisciplininė studija. Yra du skirtingi nanotechnologijos ateities scenarijai: pirmasis teigia, kad nanotechnologija sukels radikalių pokyčių; antrasis skelbia, kad nanotechnologija yra tiktai galimybių suteikimo technologija. Šiame straipsnyje tyrinėti abiejų scenarijų padariniai, tirtos kliūtys šiuolaikiškumui Irane įsitvirtinti ir nanotechnologijos poveikis šaliai.

Reikšminiai žodžiai: nanotechnologija, šiuolaikiškumas, Iranas, žinių ekonomika, prekinė priklausomybė, sociotechninė sistema, besivystančios šalys.

Sepehr GHAZINOORY is an associate professor in Department of Information Technology Management, Tarbiat Modares University, Tehran, Iran. He received his BSc, MSc and PhD in Industrial Engineering from Iran University of Science and Technology (IUST). He has authored numerous books and articles about cleaner production, strategic planning and management of technology in Persian and English. He was also consultant to the Iran presidential Technology Co-operation Office (TCO) for four years and senior consultant in formulating the Iran Nanotechnology National Initiative. He is currently a consultant to different ministries and organizations.

Reza GHAZINOURI is a master's student in social sciences research in university of Tehran. He is the head of a part of ITSMI (Information Technology Strategy Master-planning for Iran) Project and is engaged in assessing technology diffusion in Iran industry. He was a member of nanotechnology committee in presidential Technology Cooperation Office. His major research interests: sociology of technology, management of technology, social psychology and social policy making.